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THE KNEE-JERKS IN TRANSVERSE LESION OF THE SPINAL CORD.*

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INTRODUCTION.

When asked by your President to communicate a short paper to this Society, it appeared to me that no neurological problem would form a more lucrative subject for discussion than the condition of the knee-jerks in transverse lesion of the spinal cord. The reflex phenomena consequent upon this lesion differ considerably according as they are studied experimentally or clinically; and the explanations of the varied symptomatology are numerous and offer a rich field for argument and debate. The subject also, I find, has engaged your attention from time to time in its different aspects during the past few years. "The State of the Reflexes in Supralumbar Lesion of the Cord," was the subject of a paper by Dr. Fraenkel and a discussion in 1897[1]; it was incidentally mentioned by Drs. Fraenkel and Collins in a paper "On the Clinical Study of Some Reflexes,"[2] in 1900, and it was recently (1901) debated in connection with a communication from Dr. G. L. Walton upon "The Study of Spinal Fracture with Special Reference to the Question of Operative Interference."[3]

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*A paper read before the New York Neurological Society on April 8, 1902.

I propose to look at this subject rather from the experimental than from the clinical side, with the view of ascertaining how far the results of experiments upon animals may be applicable to the special phenomena of trans-lesion of the spinal cord in man; and to see whether the differences in the reflex phenomena, which are stated to exist, may not be brought into harmony with each other and explained upon general physiological principles.

As this subject has been a fruitful field for investigation and research, an extensive literature has gathered around it; but I shall deal only with a comparatively small part of the question, viz., the condition of the knee-jerks; as to go more deeply into it would involve the consideration of the whole subject of the reflex phenomena of the spinal cord, a matter more satisfactorily studied in the text-books of physiology.

Experimental Observations.—It is commonly stated that experimental cross section of the spinal cord above the lumbar enlargement in vertebrate animals leads to no immediate interference with the tendon reflexes; but that as time goes on after such operation, the knee-jerks become exaggerated, and the resulting paraplegia, which is at first of the flaccid type, assumes later on the rigid and spastic character, so commonly seen in old-standing cases of acute myelitis in man. In man, on the other hand, a fracture-dislocation of the vertebral column in the cervical and dorsal regions, is productive of permanent, flaccid paralysis of the limbs, and loss of the knee-jerks; and if the lesion be complete, no tendency at all towards rigidity or contracture.

A reference to the literature of the experimental side of the subject, however, shows, that the view expressed above is by no means universally accepted, and that much variation has been observed by experimenters upon the state of the knee-jerks, both immediately and some time after complete division of the spinal cord.

An early observation by Furbringer[4] showed that trans-section in the upper dorsal region in rabbits, was followed by lively knee-jerks, a tapping of the patellar tendon bringing about contraction of the quadriceps extensor muscle, dorsiflexion of the foot and an adductor jerk upon the same and on the opposite side.

The theory propounded by Rosenthal and Mendelsohn[5], from a number of experiments on trans-section at different levels of the cord, necessitates for the existence of the reflexes the intact connection of the afferent and efferent reflex paths with the upper parts of the spinal cord, more especially with that portion lying between the calamus scriptorius and the cervical enlargement, the "cervico-bulbar region." Destruction of the cord in or about this neighborhood interferes with the transference of the afferent impressions to the efferent paths and abolishes the reflexes. The position held by these observers is that on this account, high trans-section of the spinal cord abolishes all tendon and visceral reflexes, weakens the plantar reflex and leads to an enduring failure of the skin reflexes.

Some interesting experimental observations by Gad and Flatau[6] on dogs may here be mentioned. A brief summary only of their results is given.

These observers had no dogs in which the knee-jerks were absent during the whole period of life after the trans-section, nor any dogs in which the absence of the jerks lasted for a long time. In all the cases of high trans-section the knee-jerks were weakened, and in some temporarily abolished.

Tapping the patellar tendon in the cases in which the knee-jerks were absent sometimes caused a little urine to be expelled from the bladder; and in others there were long periods during which the knee-jerk was elicited only as a weak muscular contraction, without any extension of the limb. Comparisons were made with dogs in which the cord was divided between the dorsal and lumbar regions. In the latter, the knee-jerks were always easily obtained—a weak tap on the tendon producing an ordinary extension of the limb.

From these observations it is obvious that a weakening, or temporary abolition, of the knee-jerks is more commonly noted after high than after low trans-sections; but that in no case was a permanent abolition of the jerk observed.

But the most elaborate experiments upon this subject are those of Sherrington[7]. He has worked chiefly with monkeys, and has not only studied the condition of the knee-jerks, but has entered fully into the details of all the reflexes belonging to the portion of cord isolated by a trans-section. His main conclusions are: following trans-lesion in the region of the cervical enlargement, the skin reflexes are temporarily abolished; the knee-jerks disappear to reappear in the course of days or even weeks; and in some monkeys, as also in cats and dogs, the knee-jerks are not even temporarily abolished even in sections as high as a cervical one. His conclusion is that "shock" does not last more than a few days, but that the permanent effects of the lesion upon the isolated portion of cord are comparable to the "isolation-alteration" of Munk. This condition is probably well marked in monkeys. In man, "shock" may be more protracted than in animals, and the "isolation-alteration"speedy and severe. The prolonged loss of the knee-jerk in cases of high transverse lesion in man would seem to bear this out.

The influence of "shock" in laboratory trans-sections seems to be particularly small. As pointed out by Sherrington its effects when present are limited almost entirely to the distal parts, little, if at all, headward of the lesion; and there is little difference in the severity of the shock whether the section is in the lower thoracic, or in the cervical regions.

We now come to the suggestive experimental work of Marguliés[8]. This observer varied his experiments by producing the lesion of the cord in one of two ways, either by simple trans-section with a knife, or by squeezing or crushing the cord with a blunt instrument. His conclusions are remarkable. In all the cases (rabbits and dogs) in which the cord was cut across with a knife the knee-jerks were increased and rigidity and contracture of the hind limbs ensued.

In those in which the cord was crushed by some blunt instrument the palsy was of the flaccid type and the knee-jerks remained absent for at least a week. In a dog the jerks remained in abeyance during the three days the animal lived after the operation. In one animal the knee-jerks returned on the second day, but here the lesion was incomplete.

From these facts the deduction is made, that flaccid palsy and loss of the tendon reflexes are dependent upon the way in which the lesion is effected, and that the duration of the symptoms is in direct relation to the severity of the lesion and the position of the animal in the vertebrate scale.

It would appear from the experimental data just enumerated that a considerable discrepancy exists between the observations of different investigators, between the effects of trans-lesion in different animals as well as in those of the same species, and between the effects of trans-section even at the same level of the cord. "In the monkey," says Sherrington[9], "spinal trans-section usually depresses the knee-jerk for a longer time than in the cat or dog. Occasionally in the monkey, after trans-section at the lower thoracic region, the jerk is not elicitable for a week or so. In the cat and dog it is elicitable in a quarter of an hour or less. Spinal trans-section above the lumbar enlargement renders the jerk, after the short period of depression, more brisk than normal."

In the high trans-sections through the cervical enlargement, a crossed adductor reflex is easily and early obtained, but it does not appear as if any material difference exists in the period of absence or depression of the jerk in high (cervical) or in low (dorsal) trans-sections.

Original Experiments.—With a view to investigate this subject more fully, I have carried out a number of experiments upon monkeys during the past few months, in conjunction with Dr. Purves Stewart.

But before describing the recent experiments, attention may be called to two experimental trans-sections which were made many years ago when working with Dr. Ferrier upon experimental lesions of the cerebellum.

A. (No. 2 in the table). The spinal cord of a Macaque monkey was severed completely at the level of the eighth dorsal root. Immediately after the operation the knee-jerks were capable of being elicited as before it. There were the usual paraplegic smyptoms as regards motion and sensation. During the four months that the animal lived after the operation, the knee-jerks gradually increased in association with considerable rigidity and contracture of the lower limbs.

B. (No. 3 in the table). The spinal cord was completely divided at the level of the sixth dorsal nerve. Both knee-jerks were readily elicited immediately after the operation, if anything, more markedly than before. These observations were made for twelve days after the operation.

The recent experiments are the following:

C. (No. 4 in the table). Rhesus; complete trans-section of the spinal cord at D iv; immediately after recovery from the chloroform the knee-jerks were present and as brisk as before the operation, the lower limbs were paralyzed and flaccid.

There was a crossed adductor jerk on both sides. There was no change in the state of the knee-jerks during the succeeding five days.

As this experiment merely confirmed the previous observations it was decided to modify the operations by performing a preliminary hemi-section, examining the jerks and then completing the trans-section.

D. (No. 5 of the table). Rhesus: The cord was exposed at the level of D vii, and a right hemi-section performed. On recovery from the anesthetic, both knee-jerks were tested and appeared equal and of normal range. The monkey was again anesthetized, and the section completed. On retesting, both knee-jerks were equal and perhaps even brisker than normal. One hour later both jerks were distinctly exaggerated and accompanied by a crossed adductor jerk. Total flaccid paraplegia.

E. (No. 6 of the table). Rhesus: The cord was exposed at the level of D iv, and the right side hemi-sected; on recovery both knee-jerks were brisk, with a crossed adductor jerk in each instance.

The section was then made total. On emerging from the anesthetic, both knee-jerks were exaggerated with crossed adductor jerks. An hour later the jerks were as before. There was no change in the jerks, or in the flaccid paraplegia during the next two days.

F. (No. 7 of the table). Sooty monkey. Cord exposed and right side hemi-sected at level of D iii. With the return of the conjunctival reflex, the knee-jerks were obtained equally on both sides. Anesthesia was reëstablished and the section completed. In this case the knee-jerks were obtained with some difficulty up to half an hour after the operation. The right jerk was present with a crossed adductor jerk, the left elicited only with difficulty. Further observations were impossible as the monkey died during the night.

From these three experiments it is seen that a preliminary hemi-section did not affect the knee-jerk either upon the same or opposite side, at all events during the brief period during which the examination was made. The knee-jerks, however, appeared to be less easily obtained, the higher the level of the trans-section. A further experiment was therefore carried out.

G. (No. 8 of the table). Rhesus. Intradural trans-section at the level of D i. Immediately after the operation both jerks were present, but diminished in intensity, and failed to be elicited a few minutes later. But both crossed adductor jerks and the superficial anal reflex were obtained. Ten hours later the knee-jerks were still absent, and they were not obtained up to the death of the animal three days later, though the crossed adductor jerks were elicited throughout.

H. (No. 9 of the table). Sooty monkey. In this case the spinal cord was tightly ligatured at the level of C viii. This was done with a view to imitate, as far as possible, what occurs in fracture dislocation in the human subject. Both knee-jerks were only feebly elicited on recovery from the anesthetic; but the following reflex movements were well seen, a crossed adductor jerk, and the superficial anal reflex. Half an hour later the knee-jerks could not be elicited, nor were they obtained during the next seven hours.

As it seemed possible that the method of severing the spinal cord—by knife or by ligature—might have some influence over the resultant phenomena, a further experiment was done to control the previous trans-sections in the lower and mid-dorsal regions.

I. (No. I of the table). Rhesus. A ligature was tied tightly round the cord at D ix. The knee-jerks immediately after the operation were brisk with the presence of a crossed adductor jerk. Half an hour later, on retesting, the jerks were only elicited with difficulty, and it seemed as if exhaustion of the jerks was easily produced, for the reason that the first tap upon the tendon resulted in a fair jerk, but subsequent taps failed to show any effect. The adductor jerks and the superficial anal reflex were brisk. Ten hours later the same phenomena were noted; apparently ready exhaustion of the jerks on repetitions of stimuli. On the two days following the operation, the jerks were brisk.

One main conclusion is obvious from these experiments, viz., *that the presence or absence of the knee-jerk is influenced by the level of the trans-section*, and, perhaps of a subsidiary nature, that the method of severing the cord would appear to have some influence in determining temporarily the state of the jerks.

For the closer study of this question, I have separated in the accompanying table, the knee-jerks and the other reflex phenomena; as it would appear to be important to consider

EXPERIMENTAL TRANS-SECTION IN MONKEYS.

NO.	ANIMAL	LEVEL	METHOD	KNEE-JERKS	OTHER REFLEXES	DURATION
1	Rhesus	D ix	ligature	brisk after temporary depression	x add. jerk, superficial anal	4 days
2	Rhesus	D viii	knife	present and increasing		4 months
3	Rhesus	D vi	knife	present and brisk		12 days
4	Rhesus	D vii	hemisection section	present and brisk	x add. jerk	few hours
5	Rhesus	D iv	knife	present and brisk	x add. jerk	5 days
6	Rhesus	D iv	hemisection section	present and brisk	x add. jerk	2 days
7	Sooty	D iii	hemisection section	only with difficulty, R L.	x add. jerk	few hours
8	Rhesus	D i	knife	not obtained	x add. jerk, superficial anal.	3 days
9	Sooty	C viii	ligature	not obtained	x add. jerk, superficial anal.	7 hours

separately true reflex movements and those which may be regarded as depending upon neuro-muscular tonus.

As soon as the monkeys emerge from the chloroform anesthesia, if the lesion has been made at or below the level of the fourth dorsal segment, the knee-jerks are elicited, and may even be more vigorous than previously, a crossed adductor jerk is always readily obtained, as well as frequently on the same side, and pricking the perineum leads to protrusion and contraction of the sphincter ani. Micturition, which may at first have been temporarily in abeyance, occurs at definite intervals and defecation is regular. Patulousness of the anus is rare, and if it occurs, is of quite temporary duration (Sherrington). The limbs are in a state of flaccid palsy; as time goes on rigidity and contracture ensue and the knee-jerks become decidedly exaggerated. Sensation is abolished in the parts below the level of the lesion.

In the higher trans-sections, those made about the level of the second and third dorsal segment, some difficulty was experienced temporarily in eliciting the jerks. In Exp. 7 the right jerk was more readily obtained than the left; and both seemed to be easily exhausted, that is to say, frequent and repeated attempts to elicit the jerks, failed to evoke any response after the first or second tap. But from both patellar tendons a crossed adductor jerk was easily brought about. Defective knee-jerks were present up to half an hour after the operation.

In still higher cases—trans-section at the level of the first dorsal and eighth cervical segments—the knee-jerks could temporarily be obtained with difficulty, but in both instances they entirely failed within the first quarter or half an hour after the trans-section.

This is readily explained on the hypothesis that the spinal segments retain some degree of autonomy after severance from their connections, however high the lesion may be. This also accounts for what is now generally admitted, that the knee-jerks may be present for one or two minutes after decapitation.

A brief comparison may now be made with the clinical picture presented by a case of fracture dislocation at the level of the eighth cervical segment. In addition to the complete motor and sensory paralysis of the lower limbs, the knee-jerks are not obtained; the bladder requires to be evacuated by the catheter; the anus is patulous and does not grip the examining finger, and there may possible be incontinence of feces; there is usually marked priapism. On the other hand, a plantar reflex of the extensor type will be obtained on stroking the sole of the foot, and the superficial anal reflex will be present on pricking the skin of the perineum.

The paraplegia is of the flaccid type, and if the trans-section is complete, remains so, and the knee-jerks do not return.

Various theories have been advanced to explain the condition of flaccid paralysis and loss of the knee-jerks in complete trans-sections in man.

Many of them, though supported by considerable pathological evidence, may be at once dismissed. For example, all those cases have been eliminated* in which there was obvious interference with the reflex arc in its intra-spinal course, as well as those which showed asociated degeneration of the anterior roots and of the peripheral nerves. No reference either is made to those cases, and there are several on record, in which a descending myelitis, or a coexistent lumbar myelitis was present. In this way the number of cases presenting the salient features of flaccid palsy and loss of the knee-jerks is reduced to those of sudden traumatic lesion (usually fracture dislocation of the vertebral bodies) in or about the region of the cervical enlargement.

The most commonly accepted explanation is the Bastian-Jackson[10] view, which ascribes the loss of the reflexes to the cutting off of cerebral and cerebellar influence. The acceptance of this explanation depends upon the completeness of the trans-section and the permanent abolition of the tendon jerks. As regards the latter point, I believe the evidence is conclusive, viz., that in no case in which the cord has been completely severed has any return of the tendon jerks been observed. This statement is based upon the writings of Bruns[11], who has analyzed most of the recorded instances of this condition. But evidence will be brought forward presently to show that abolition of the knee-jerks even for prolonged periods, may be occasioned by anatomically incomplete trans-sections, proved post-mortem to have been such.

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*An extensive bibliography and criticism of the recorded cases will be found in Neurol. Centralbl. 1897, p. 72.

Bastian's explanation further implies that the knee-jerk is directly dependent upon the function of the cerebellum in maintaining the muscle tonus, acting upon and through the spinal centers. Removal of the cerebellum should therefore theoretically on this view produce hypotonia, and consequently loss or impairment of the knee-jerks. Now atonia has been stated by Luciani[12] to be one of the phenemona following cerebellar extirpation, though he does not seem to have tested the knee-jerks in this connection. If the state of the knee-jerk indicates the degree of neuro-muscular tone, as is generally admitted to be the case, then its exaggeration, after cerebellar extirpation, as shown by Ferrier and myself[13], as well as by Risien Russell[14], would prove not atonia, but a state of hypertonicity, following complete removal of this organ.

It is difficult also to believe that if the cutting off of the combined cerebral and cerebellar influence abolishes permanently the tendon jerks in man, why their abolition is not more constantly observed after cross section of the spinal cord in the higher vertebrate species such as the monkey. But the evidence from experiments already quoted shows that this is not a necessary, nor indeed a common, result; and that it depends largely upon the level at which the section is performed.

All observers are agreed that even in those animals in which the knee-jerks are temporarily abolished or weakened, their reappearance is merely a question of time, but there are many instances, even in apes, in which no interference with the reflex activity has been observed, even temporarily, after spinal trans-section.

Incomplete Lesions.—Some valuable information upon the loss of the knee-jerks may be obtained from a study of partial trans-lesion of the spinal cord following fracture dislocation, that is to say, cases in which the symptoms indicate a complete physiological trans-section for a period, but which are shown by subsequent post-mortem examination to have been anatomically incompletely divided. Instances of partial trans-lesion with loss of the knee-jerks have been recorded by Thorburn[15] and others, but without sufficiently definite pathological data. I propose first to refer to a case already recorded by Dr. Purves Stewart[16], examined pathologically in detail. Briefly the history of this case is as follows:

A woman, *aet.* 28, fell out of a window, a distance of about twenty-five feet, and dislocated the body of the fifth cervical vertebra. This was followed by complete flaccid paraplegia and anesthesia below the level of the third rib, and partial paralysis of the upper limbs. The breathing was entirely diaphragmatic. The knee-jerks were absent, as also were the abdominal and epigastric reflexes. The plantar reflex was present and of the extensor type. There was complete retention of urine. The superficial anal reflex was present on pricking the skin of the perineum; but the deep anal sphincter was paralyzed; the anus "yawned" after withdrawal of the examining finger. The leg muscles responded readily to faradic excitation.

Up to forty days after the injury, the symptoms indicated a complete physiological trans-section of the spinal cord, but at this date, the return of the knee-jerks, at first slightly, and then with greater intensity, seemed to point to an anatomically incomplete lesion. With the return of the knee-jerks, there ensued some contracture and rigidity, but without any voluntary power over the lower limbs. The patient died sixty-eight days after the accident.

The examination showed that the cord, at the seat of compression, was reduced to a mere ribbon, measuring about 1 mm. thick; while microscopically, a thin strand of degenerated white fibers, situated peripherally, joined the proximal and the distal segments. It was obviously not a complete spinal trans-section.

The second case, not previously recorded, was under the care of my colleague, Dr. Howard Tooth, in the Queen Square Hospital, and I am indebted to him for permission to publish it.

The patient, G. M., while working on a ladder, lost his balance and fell from a height of twelve feet, striking his back and shoulders; there resulted a paraplegia, and anesthesia from the level of the umbilicus on the right side, and from a point two inches below on the left side. There was retention of urine requiring catheterization. The knee-jerks were not obtained, the abdominal skin reflexes were also absent, but the plantar reflex was present and of the extensor type. There was tenderness on pressure over the sixth, seventh and eighth dorsal spines. These observations were made twelve days after the injury on his admission to the Hospital for the Paralyzed and Epileptic; and the symptoms persisted, without any material change, for four months, when the knee-jerks were noted to have returned. Three months later (*i.e.*, seven months after the accident) the legs had lost their flaccidity and showed rigid extension and occasional jumping movements. There was also some voluntary power over the toes and of rotation at the hips. The knee-jerks were present and the plantars were of the extensor type. Four months later—a year after the accident—there was no return of sensation, but the patient was aware when his legs were moved. He died sixteen months after the accident.

Dr. Collier, who examined the cord after death, reports as follows: There was a fracture dislocation of the body of the eighth dorsal vertebra. Between the eleventh and twelfth dorsal roots there was a depression in the cord about 1 cm. wide, the cord being here reduced to a mere ribbon. Microscopically there was no portion of the lesion free from medullated nerve fibers, undergoing degeneration. The proximity of the ends of some of the fibers suggests that there might have been continuity, though no continuous axis cylinders could be detected. The spinal segments showed absolutely no change to the Nissl reagents, except in immediate relation to the site of lesion. The usual ascending and descending degenerations were noted.

The points of special significance illustrated by these two cases, well examined both clinically and microscopically, are, in relation to the matter attracting our present attention, the following:

1. The symptoms, as regards motion, sensation and the

type of palsy, are indicative of a complete physiological trans-section of the spinal cord, above the lumbar enlargement.

2. The immediate and prolonged loss of the knee-jerks in the first case for forty days, in the second for four months, with retention of plantar reflexes of the extensor type.

3. With the return of the knee-jerks a tendency to muscular rigidity, contracture and spasm though not necessarily of any voluntary power.

4. The incompleteness of the anatomical lesion with pronounced descending degenerations in the crossed pyramidal and antero-lateral descending tracts.

5. And, finally, the absolutely healthy appearance of the cells of the lumbar enlargement according to the Nissl method.

The Plantar and Skin Reflexes.—This is a convenient place to refer briefly to the condition of some other reflexes, viz., the superficial skin, and the plantar reflexes. The state of the skin reflexes after trans-section of the spinal cord is variable. In some, they are abolished, in others retained, and at times they are increased. As even in healthy individuals the skin reflexes are an uncertain quantity, little assistance is rendered by them in this connection. Very different, however, are the lessons to be learned from an examination of the plantar reflex. This reflex is present in trans-sections above the lumbar enlargement in man. In the cases recorded prior to the description by Babinski of the flexor and extensor types, the general statement was made that a plantar reaction was present; but in those recorded subsequent to that date, the statement is definitely made that the plantar reflex was of the extensor type. In other words, trans-section of the spinal cord is not followed by abolition of so pure a reflex as is the plantar reaction. From the experiments, which I have recorded in this paper, the following other reflexes may be added to the list of those which are not abolished by trans-section. The crossed adductor, and the superficial anal or perineal reflex. This latter reflex has been found present also in trans-lesion in man.

CONCLUSIONS.

The conclusions which it is possible to draw from a consideration of the foregoing experimental and clinical observations may be briefly stated as follows:

1. The condition of the knee-jerks after experimental trans-section of the spinal cord in monkeys is not constant: the higher the level of the trans-section, the greater the likelihood of the knee-jerks being temporarily diminished or abolished. In these observations there is found a confirmation of the experimental data given by Rosenthal and Mendelsohn and by Gad and Flatau in dogs.

2. No such difference according to level is found in trans-sections of the human spinal cord; all complete trans-sections above the lumbar enlargement lead to abolition of the knee-jerks, most probably of a permanent character.

But temporary abolition of the knee-jerks, sometimes for a prolonged period, may follow incomplete anatomical trans-section, although the other coexistent phenomena point to a complete physiological lesion.

3. In man, as experimentally in monkeys, although the knee-jerks may be abolished, some true reflex actions are permanently maintained; such are the plantar and the superficial anal reflexes; and, notably in monkeys, the crossed adductor jerks.

4. Accepting the view that the state of the knee-jerk indicates the degree of the neuro-muscular tone, if some other muscular action dependent upon "tone" is found to be abolished in spinal trans-section as well as the knee-jerks, it may legitimately be argued that neuro-muscular tonus is impaired or abolished in physiological trans-section; such other atonic paralysis is, I submit, to be found in the "yawning" of the anus, which has been described.

5. Therefore, we may conclude that in spinal trans-section in man, and in high trans-sections in monkeys, actions dependent upon neuro-muscular tone are permanently or temporarily abolished; but that true reflex movements are not impaired.

6. The variation which exists in the phenomena following

lesion at different spinal levels in dogs and monkeys, the transitory effects of such lesions as regards the knee-jerks, as well as the temporary abolition of the knee-jerks in incomplete lesions in man, would preclude the general application of Bastian's theory; for there is nothing yet recorded to negative the view that the mechanism which produces loss of the knee-jerks in man, or their temporary abolition in the lower animals, is not to be found in the spinal cord itself.

7 The explanation of the discrepancy which exists between the results of trans-section in laboratory animals and man may be explained by the greater autonomy of the spinal segments in maintaining neuro-muscular tonus as we descend the vertebrate scale.

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